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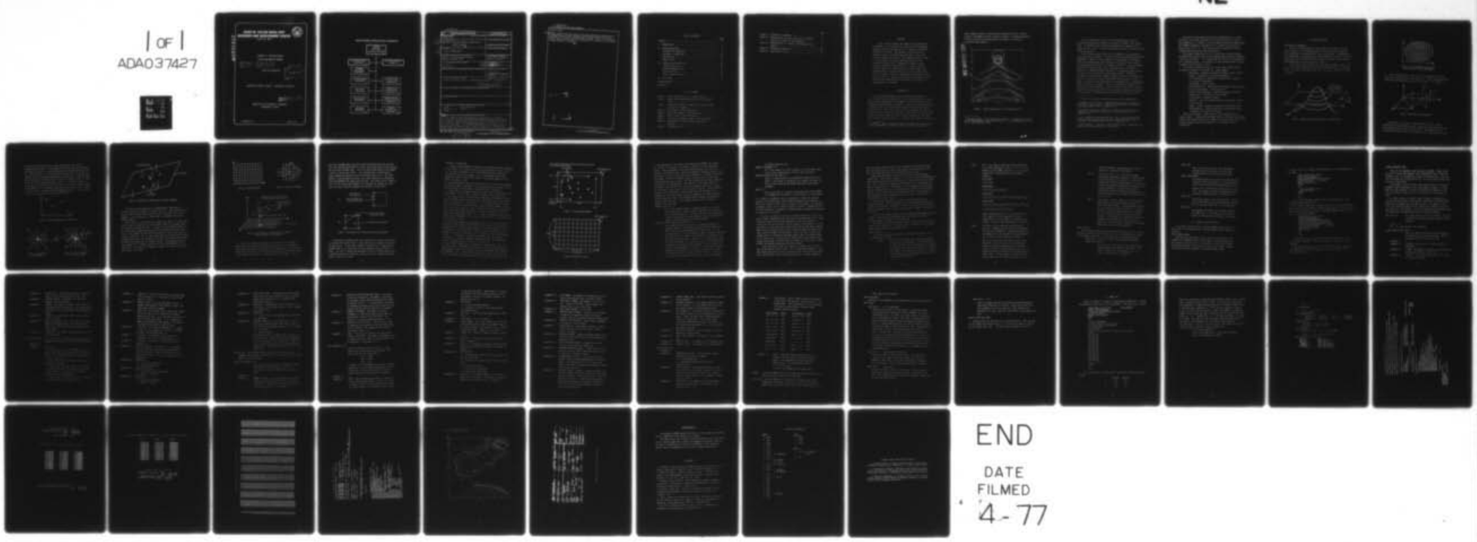

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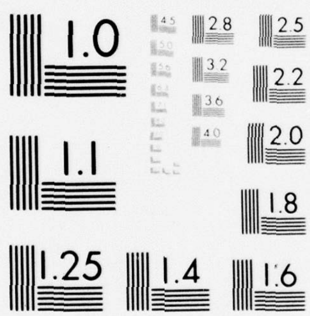

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CONTOUR II: A REVISED SURFACE FITTING AND MAPPING PROGRAM

Mary Beth Marquardt

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COMPUTATION AND MATHEMATICS DEPARTMENT

DEPARTMENTAL REPORT

OCTOBER 1976

CMD-76-26

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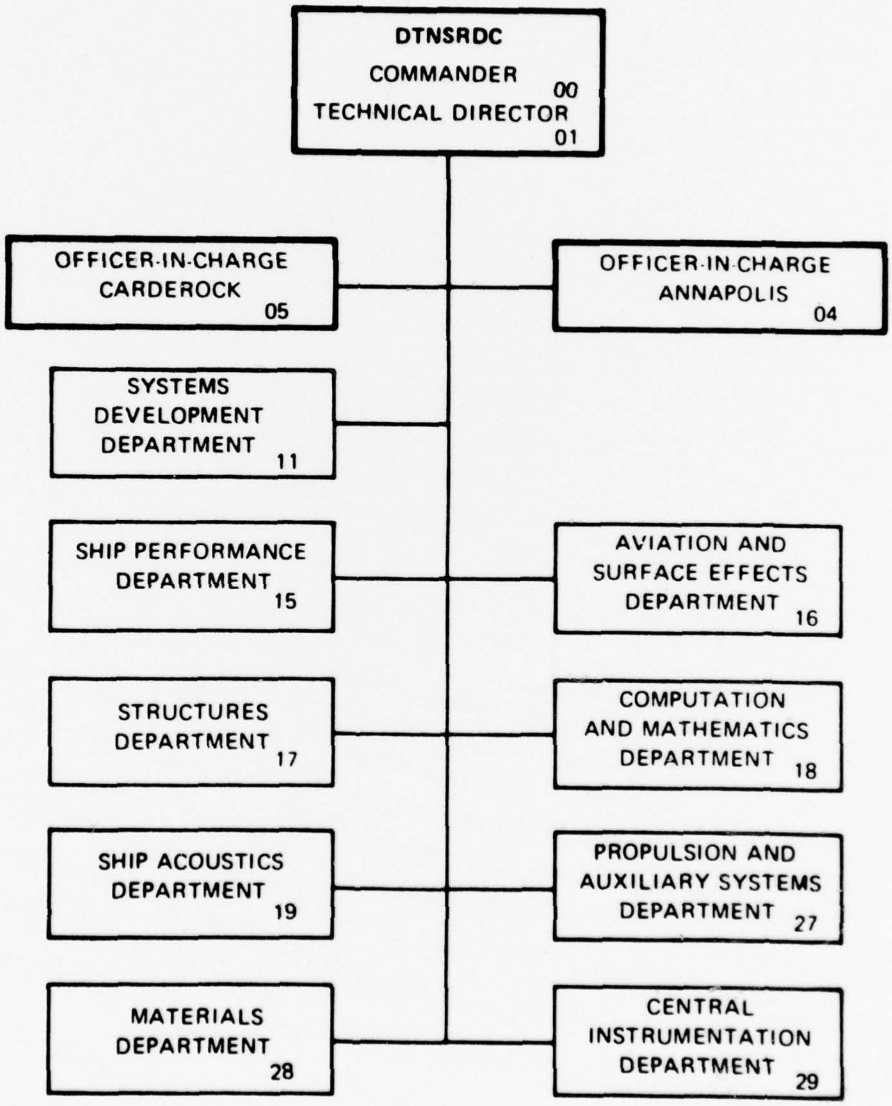

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CMD-76-26	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CONTOUR II: A REVISED SURFACE FITTING AND MAPPING PROGRAM		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Mary Beth Marquardt		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS David W. Taylor Naval Ship R&D Center Bethesda, Maryland 20084		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61153N, 15321, SR0140301, Work Unit 1-1808-010
11. CONTROLLING OFFICE NAME AND ADDRESS (12) 46p.		12. REPORT DATE (11) October 1976
		13. NUMBER OF PAGES 46
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED. (16) RØ14Ø3

(17) SRØ14Ø3Ø1

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Contour
Surface Fitting
Mapping
Three-dimensional
Graphics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the capabilities and operation of CONTOUR II, a revision of the surface fitting and mapping program originally developed by Mr. A. Beharell, now at the University of Calgary. The program is designed to fit a geometric surface in three-dimensional space to any given set of coordinate data points. The computed "smooth" surface is then displayed by drawing specified contours on the Calcomp 936 drum plotter. Although this manual includes material contained in the University of Calgary report on

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A

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ABSTRACT

This report describes the capabilities and operation of CONTOUR II, a revision of the surface fitting and mapping program originally developed by Mr. A. Beharell, now at the University of Calgary. The program is designed to fit a geometric surface in three-dimensional space to any given set of coordinate data points. The computed "smooth" surface is then displayed by drawing specified contours on the Calcomp 936 drum plotter. Although this manual includes material contained in the University of Calgary report on CONTOUR, emphasis has been placed on the input changes and additions made to facilitate the use of this program on the CDC 6000 computer systems for engineering calculations of fluid dynamics problems. Details are presented of the control cards and input data preparation for operation of the program. A sample problem is included.

I. INTRODUCTION

The contouring technique to be described was developed by Mr. A. Beharell and later modified by him at the University of Calgary.[1] His program was purchased by the Computer Facilities Division of the Computation and Mathematics Department. Because of extensive interest in a general purpose, versatile contour mapping program in the Numerical Fluid Mechanics Branch (Code 1843), the tape containing the code and a copy of the User's Manual were obtained. The program was then modified to more efficiently meet the needs of several projects in the Branch which required contour diagrams. For example, the CONTOUR II program was

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[1] "CONTOUR, A Surface Fitting and Mapping Program," The University of Calgary, Department of Computer Sciences, CSUG-049 (February 1976).

used to obtain pictures of wave patterns generated by an Air Cushion Vehicle,[2] an example of which is shown in Figure 1. Another application of this versatile plotting program has been made in the area of structural stress analysis.

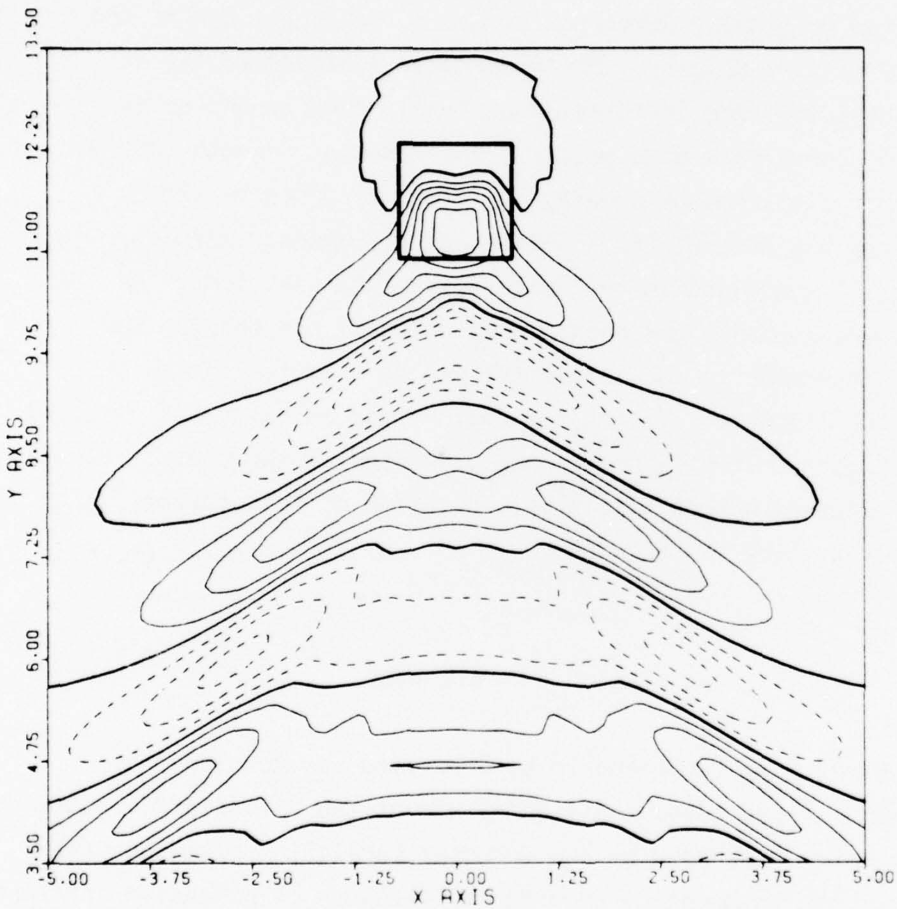

Figure 1. Waves Generated by an Air-Cushion Vehicle

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[2] Haussling, Henry J. and VanEseltine, Richard T., "Unsteady Air-Cushion Vehicle Hydrodynamics Using Fourier Series," J. of Ship Research, Vol. 20, No. 2, June 1976, pp. 79-84.

A major change made in the original CONTOUR program involved dividing the program into "tasks"* to reduce the computer core requirements. In addition, the fixed input arrangement was changed to free format for ease of use. An extra input card was added to provide several additional options.

The resulting program, which we call CONTOUR II to distinguish it from the original version, is a surface fitting and mapping program which complements a number of other graphics tools developed in the Branch. These other programs make use of both passive and interactive graphics and combinations of the two. For example, XYZPLOT[3] is a passive graphics program for displaying the results of potential flow calculations. ENGPLOT[4] is a computer program subroutine for generating graphs of data in formats which are useful for engineering studies. DESIGN[5] was developed as an interactive computer graphics package for displaying and modifying projections of three-dimensional representations of vehicle models. DESIGN has since been modified and enhanced into a comprehensive, modular program called IMAGE.[6] IMAGE is an interactive program incorporating the three-dimensional features of DESIGN and also providing two-dimensional graphing capability for representing FORTRAN arrays of data as cross plots. SC 4060 and Calcomp hard copies are easily obtained.

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* A task is a section of code which may be executed independently.

[3] Morawski, Paul, "XYZPLOT: A Three-Dimensional Graphics Package for Fluid Dynamics Calculations," Computation and Mathematics Department, Departmental Report CMD-15-75 (August 1975).

[4] Marquardt, Mary Beth, "ENGPLOT: An Engineering Plotting Program," Computation and Mathematics Department, Technical Note CMD-9-74 (February 1974).

[5] Kelly, Barbara M. and Marquardt, Mary Beth, "Interactive Helicopter Design: Geometry Package User's Manual," Computation and Mathematics Department, Departmental Report CMD-28-74 (September 1974).

[6] Haas, Melvin E., "Interactive IMAGE Display System," Computation and Mathematics Department Report (in preparation).

Any series of data points which can be represented by X, Y, and Z coordinates (or digital triplets) can be used to describe a surface in three dimensions. A contour is the line connecting points of equal value. The CONTOUR II program is designed to fit a surface to any series of digital points (X, Y, Z). This surface is then displayed for visual examination by drawing the specified contours.

The surface is generated by first calculating a series of planes through the data points using various weighting factors and then imposing a grid over the planes. It is assumed that the result of this operation is a continuous surface. The contours are then smoothed before plotting to provide a more realistic picture.

This type of program has been used in many areas where graphical expression is helpful in data analysis. Some examples:

- Meteorology - barometric pressure and other climatic factors.
- Geology - topographic and subsurface mapping.
- Civil Engineering - location of structures with respect to such areas as topography.
- Oceanography - water salinity.
- Space Exploration - representation of magnetic field intensity.
- X-Ray Crystallography - electron density.
- Medical X-Ray Technology - radiation intensity within the human body as a result of x-ray treatment.
- Air Pollution - pollution indices.
- Fisheries - catch of different types of fish within a given time interval.
- Census - census information, population and related items.
- Fluid Mechanics - surface elevations, equi-potential lines, streamlines, pressure distributions.

Much of this report is taken directly from the University of Calgary report. Changes have been made mainly in the input description. Control Card examples reflect the DTNSRDC CDC 6000 operating system. The original Calgary version was inoperable on the computers at our installation.

II. SYSTEM DESCRIPTION

THE METHOD OF CONTOURING

In order to take advantage of the flexibility of control over parameters involved in the contouring process, the user should be familiar with the method of transforming data into a contour map. A contour map is a two-dimensional representation of a three-dimensional surface, derived by drawing the lines of intersection of a series of parallel planes with the three-dimensional surface (see Figures 2 and 3).

In the description following, the Cartesian coordinate system will be used. It will be assumed that the series of parallel planes is parallel to the X,Y-plane, and intersect the Z-axis at regular intervals as shown in Figure 2.

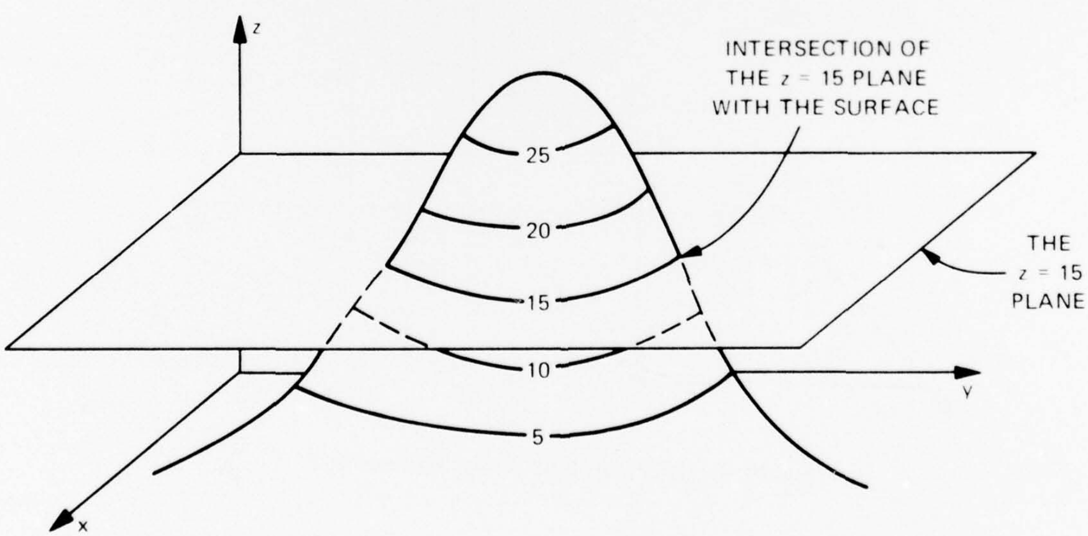


Figure 2. Sample Three Dimensional Surface Cut by Parallel Planes

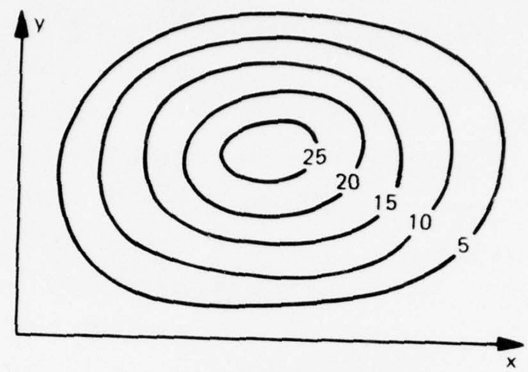


Figure 3. Contour Map Produced by Mapping Intersection Lines of Planes with Surface

The contouring process uses a set of user supplied DATA POINTS. These are a series of points, described by X, Y, and Z coordinates which define the three-dimensional surface to be mapped. (See Figure 4).

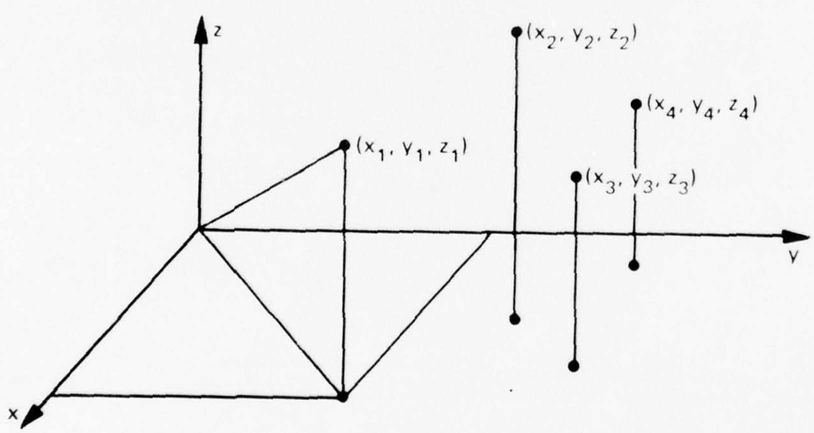


Figure 4. Data Points in Three Dimensions

The problem is to create a CONTOUR SURFACE, that is, a three-dimensional surface which best passes through the given DATA POINTS, and best predicts trends between the data points. Approximation of the CONTOUR SURFACE begins with the determination of a PLANE surface at each

DATA POINT, which best reflects trends suggested by the closest neighboring DATA POINTS. To determine the PLANE surface at a particular DATA POINT, consider the two-dimensional map of the DATA POINTS in the X,Y plane (Figure 5). The area around each DATA POINT is divided into OCTANTS, that is, 8 equal pie-shaped pieces (Figure 6). In each of these OCTANTS a search is conducted for the closest NEIGHBOR in the X,Y plane to the DATA POINT being considered (Figure 7). The PLANE surface is chosen to pass through the DATA POINT and to pass "most closely" through the NEIGHBORS, with a weighting scheme used, such that the PLANE surface fits more closely to nearer chosen NEIGHBORS (Figure 8). Thus, a PLANE surface is associated with each given DATA POINT.

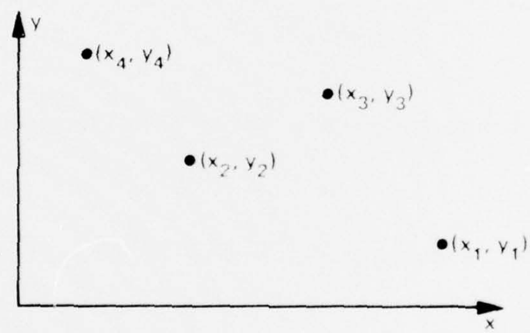


Figure 5. Data Points Mapped in Two Dimensions

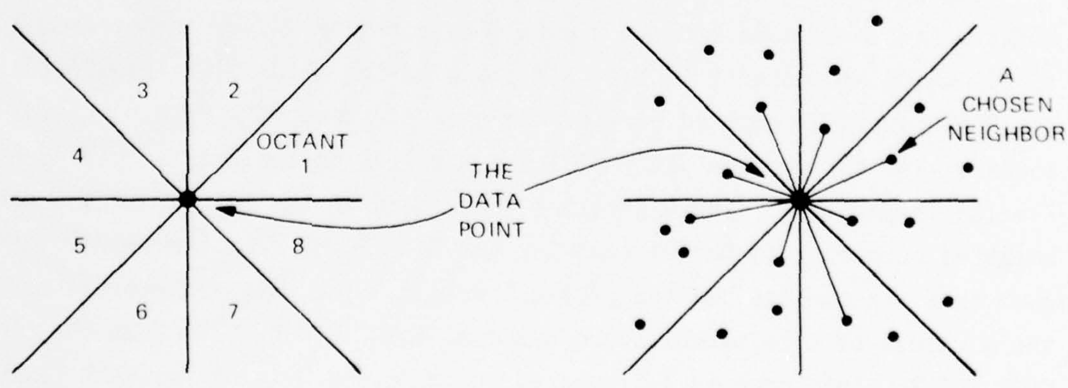


Figure 6. Octants about a Given Data Point

Figure 7. Selection of Neighbors about a Given Data Point

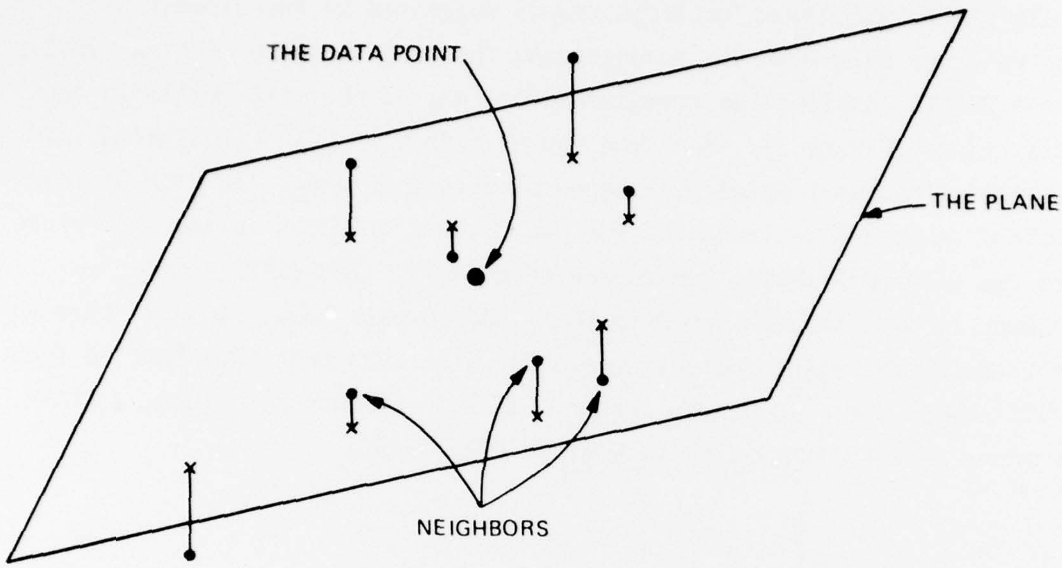


Figure 8. Determination of Plane Surface Using Chosen Neighbors

The next stage in computing the CONTOUR SURFACE superimposes a regularly spaced grid on the X,Y plane (Figure 9). Each intersection of the grid lines defines a GRID POINT at which a GRID VALUE or Z-value is computed. The resulting set of GRID VALUES is assumed to define the CONTOUR SURFACE.

The Z-value at each GRID POINT is computed as follows. At each GRID POINT a search is made for the N DATA POINTS (where N is a number from 1 to 20) which are nearest in the X,Y plane to the GRID POINT (Figure 10). The PLANE surface computed earlier for each of these DATA POINTS intersects a line through the GRID POINT and parallel to the Z-axis, giving a Z-value (Figure 11). The N Z-values thus found at the GRID POINT are each weighted according to the distance of the DATA POINT from the GRID POINT such that the closest has the greatest weight. The weighted average of the N values of Z is taken as the value of the CONTOUR SURFACE at the GRID POINT. This process is repeated to compute a Z-value for each GRID POINT on the X,Y plane.

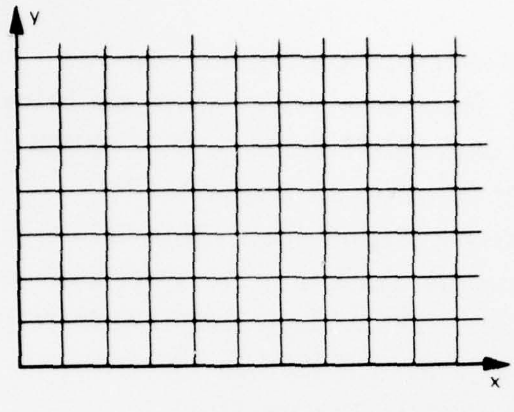


Figure 9. Superimposed Grid

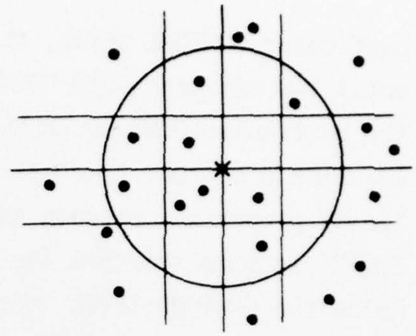


Figure 10. Selection of Neighbors

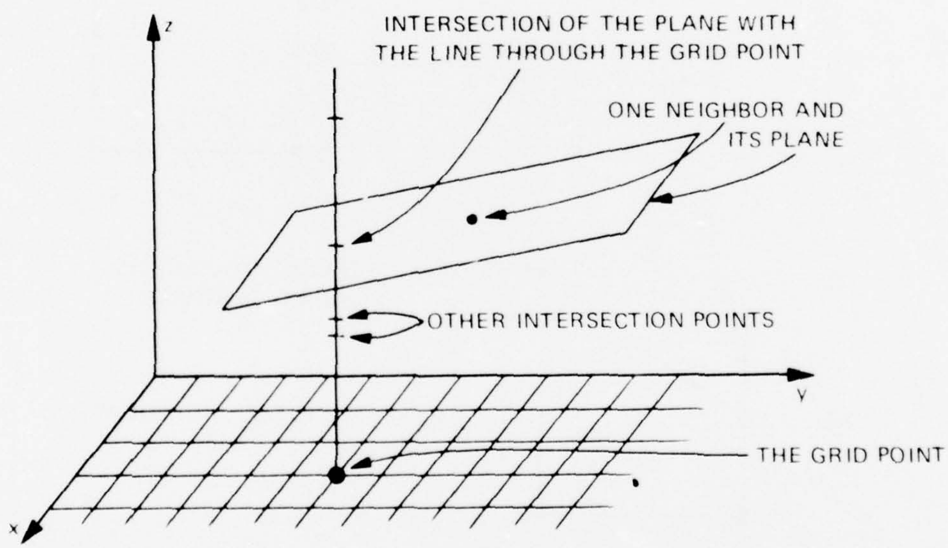


Figure 11. Determination of Contour Value at a Grid Point Based on the Planes of the Neighbors

Having thus determined regularly spaced values of the CONTOUR SURFACE over the entire map region, the next step is to represent the three-dimensional surface so defined in two dimensions as a contour map. Placement of the contour lines on the map proceeds with the consideration of the CONTOUR LEVELS, one at a time, from lowest to highest. For a

particular CONTOUR LEVEL, the GRID VALUES determined above are searched until two adjacent GRID POINTS are found which have values above and below the particular CONTOUR LEVEL. These two GRID POINTS define a GRID SQUARE in which a contour line starts. The starting point is determined by linear proportion between the two GRID POINTS (Figure 12a). This GRID SQUARE is then searched for another side whose end points lie above and below the CONTOUR LEVEL under consideration. The contour line is made to exit from the current GRID SQUARE to an adjacent one through this side, again by linear proportion between the end points (Figure 12b).

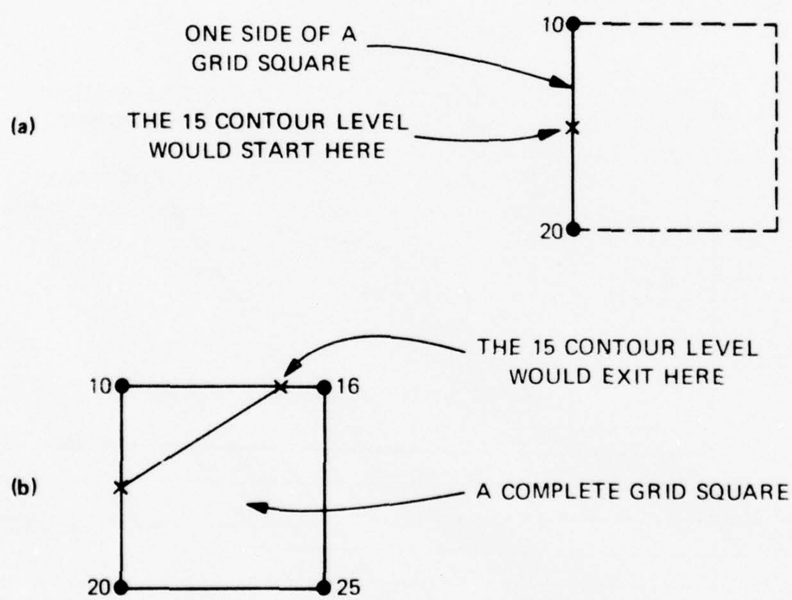


Figure 12. Determination of a Contour Line through a Grid Square

The particular CONTOUR LEVEL line proceeds from adjacent GRID SQUARE to adjacent GRID SQUARE until it closes on itself or reaches the edge of the map region. At this point, another starting point is found for the CONTOUR LEVEL or, if these have all been exhausted, the next level is begun. In order to improve the appearance of the resulting contour lines a smoothing function is applied, so that a series of straight lines and angular corners is avoided.

DESIGNING A CONTOUR MAP

Several factors should be taken into consideration before attempting to fill out a set of control cards for the contouring of a set of data:

1) In order to introduce a set of DATA POINTS into the contouring program, they must be assigned X, Y, and Z coordinates using some convenient system of units (DATA UNITS). The maximum number of DATA POINTS in one map is 998.

2) The map boundaries must be ascertained either by studying the maximum and minimum X and Y coordinates, or by examining an existing map of the area which shows the positions of the DATA POINTS (Figure 13).

3) A value must be assigned to the lower left corner of the map in X and Y DATA UNITS. (This is the X ORIGIN, Y ORIGIN on the control card).

4) The distribution of the DATA POINTS should be studied and the size of the GRID SQUARES, which the program will superimpose on the map surface, should be determined. A good rule is to try to make the grid size such that no more than one DATA POINT falls within each GRID SQUARE. However, this is not always practical, since the data may be densely concentrated in some areas and sparse in others. In a case like this it is best to choose some intermediate value. It is strongly recommended that square or nearly square rectangular cells be used. The grid size is defined on the control card as X GRID.

5) Another consideration in determining grid size is the fact that the program will only handle 6500 GRID POINTS. The number of GRID POINTS is determined by dividing the total number of DATA UNITS along the X-axis by X GRID VALUE to give the number of COLUMNS-1, and dividing the total number of data units along the Y-axis by Y GRID VALUE to give the number of ROWS-1. The product of the ROWS and COLUMNS gives the number of GRID POINTS. In general, doubling the number of rows and columns will increase computer time by a factor of 4 (Figure 14).

6) The CONTOUR INTERVAL may be determined by examining the range and variation of the Z coordinates of the data. Usually a map with densely packed contour lines is not pleasant to look at and takes much longer on the computer. Also, if the contour interval is chosen too fine for the data, the smoothing algorithm used may cause some contour lines to cross.

VALUE AND Y GRID VALUE IN DATA UNITS AND X GRID SIZE AND Y GRID SIZE IN INCHES

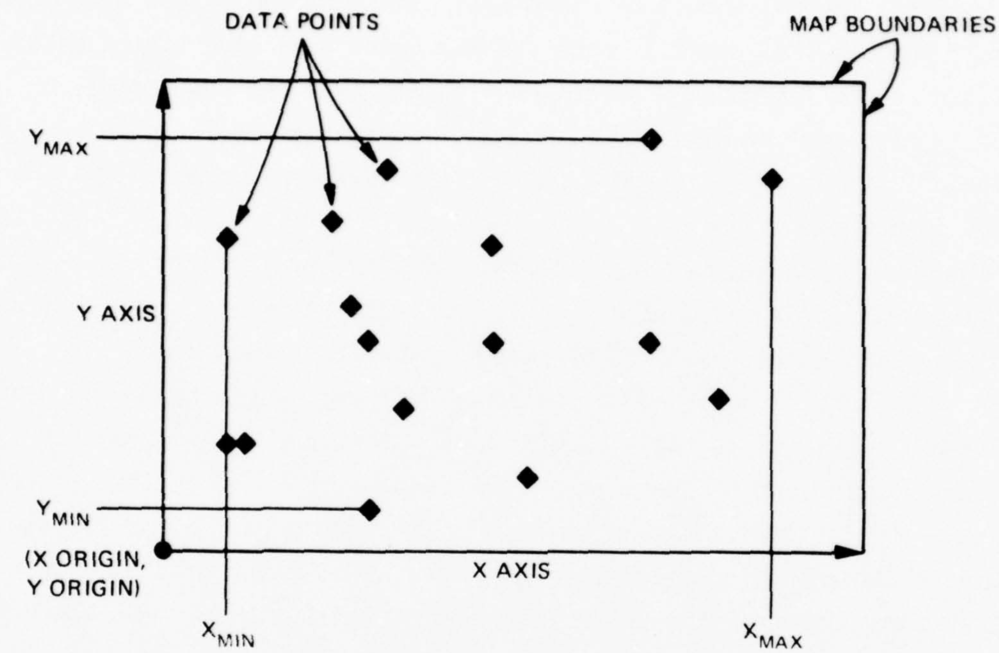


Figure 13. Choosing Map Boundaries

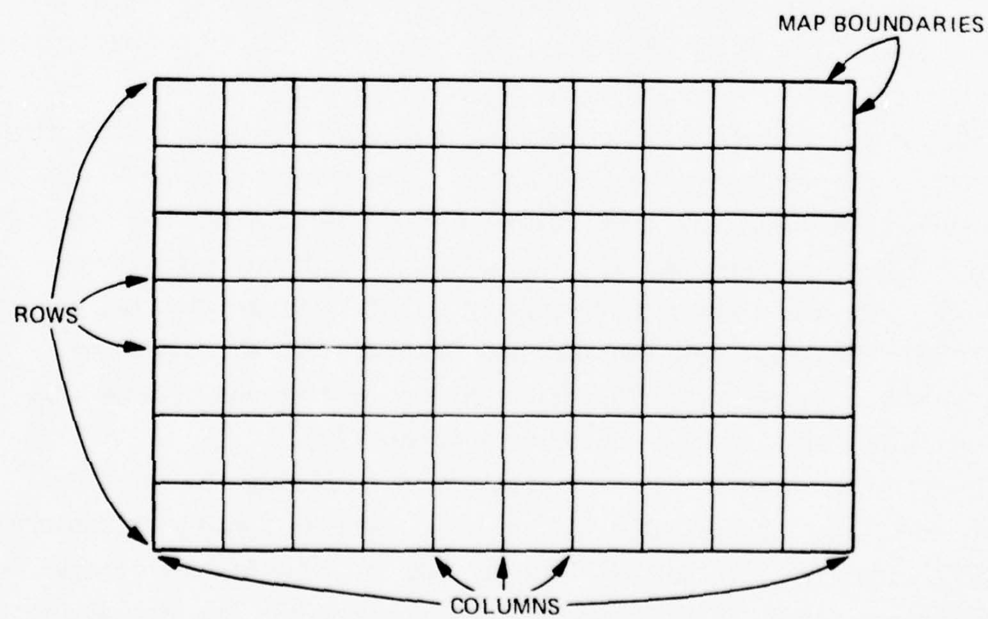


Figure 14. Selection of a Grid

7) The appearance of the contour map produced by CONTOUR from a given set of data is controlled by a number of parameters in the contouring process. These parameters can be modified by the user, as desired, to achieve a satisfactory map. Control of CONTOUR is designed so that,if the user does not select a value for certain parameters, a standard value will be assumed. This set of standard values has been chosen to give good results with most sets of data. The user should also note that contouring is a process of approximation. The accuracy of this approximation is affected to some extent by the choice of parameters and also, of course, by the accuracy and density of the data points supplied. Some increase in accuracy can be achieved by choosing other than the standard set of parameters. This will usually cause the program to run longer and hence be more expensive to use. The following notes indicate the parameters which the user may alter. The standard value for each is shown in brackets after the name.

NUMBER OF OCTANTS (5)

This is the minimum number of octants around each DATA POINT which must contain a neighbor before that point is considered in the contouring process. If the point meets this requirement, a PLANE surface will be fitted through it which will eventually influence the determination of the GRID VALUES.

WEIGHTING FACTOR FOR THE DATA POINTS (-2)

As mentioned in the description of the contouring method, a weighting scheme is used which causes the PLANE surface to fit more closely the chosen neighbors to a DATA POINT. For the standard value of -2, this weighting scheme is roughly equivalent to using the inverse square of the distance of neighbors from the point being evaluated. A value of -1 is roughly equivalent to linear weighting. If a value of 99.999 is entered here, the weighting will be completely eliminated. Positive values and zero are not recommended. The effect of increasing the weight (making it more negative) is to force contour lines to more accurately honor the given DATA POINTS. However, in areas of sparse data an increase in weight often causes the appearance

of extreme highs and lows.

NUMBER OF NEIGHBORS (10)

This is the number of closest neighbors to a grid point, which will be used in determining a value at that grid point.

WEIGHTING FACTOR FOR THE GRID (-2)

Used in a similar manner as the WEIGHTING FACTOR FOR THE DATA POINTS. This weight is applied to the Z-values calculated for the grid point based on the PLANES from each of the chosen neighbors.

RANGE (5.)

This is the radius, in inches, within which the closest NUMBER OF NEIGHBORS must be found, if a grid point is to be evaluated.

8) A number of parameters are also available to control the plotted output on the contour map. Some of these parameters may be omitted in which case standard values will be assumed by the program. The following paragraphs suggest some of output variations possible. Complete details of these parameters, including the standard values assigned by the program, are described in section 3.

The user may choose to include or omit the plotting of a title, the axes, a symbol marking the exact location of each data point, the Z-value of the data point (which may be placed in a variety of positions relative to the exact location), and the values of the contours. He may also choose to have some contour lines drawn heavier than others and may choose to omit contours of less than a specified length or based on less than a specified number of data points. Unless the user overrides the standard choice of minimum and maximum contour lines, by entering these on the control card, the program will choose these limits based on the maximum and minimum Z-values of the DATA POINTS (or if the data is GRID POINTS, the maximum and minimum GRID POINT values).

A special feature allows the plotting of a single set of contour data as two separate contour maps. This is called MAP SEPARATION. The most common application of this feature would be in the case of residual maps, which involve Z-values above and below zero. If MAP SEPARATION

were specified at contour level zero, two contour maps would be drawn. The first would show all contour levels below zero, and the zero line. The second would show the zero line, and those above zero.

Some additional options give the user several useful plotting capabilities. One of these features is referred to as MAP SUPERIMPOSITION, which allows two different sets of data to be plotted on the same contour map. This is useful for comparison of contours or for elimination of a specific contour level. For example, if it was beneficial to eliminate the zero contour level, the user would specify negative lower and upper contour limits on the data cards to produce the first map and positive lower and upper limits on the next set of data cards (with the MAP SUPERIMPOSITION flag set to 1).

The user may also specify a "noise" tolerance based on data generation errors. With this option the user can eliminate meaningless contours from the map. A default is used if no value is specified; that means a tolerance value is preset in the program if none is specified in the input.

The user may request dashed lines for contours representing negative values by specifying a dash pattern and a dash length in inches. A default length is already set in the program.

Body outlines may be drawn on the map by inputting the file number where the user has set up X,Y points. Gaps or "holes" may be specified. Outline points must be in user data units.

INPUT OPTIONS

Five types of input are available in the CONTOUR program. These are described as follows:

Type 1 — This is the standard type of input most commonly used: The X,Y,Z coordinates. This information can be read from any file containing one set of values per record. The format of the data may be read in free format or as specified by the user. The end of the input data is indicated by a final record containing the characters 99.

Type 2 This is for input in the form of the coefficients of a surface equation of order 1, 2, 3, or 4. The number of coefficients required is 3, 6, 10 and 15, respectively, corresponding to the following formulae:

First Order

$$Z=C_1+C_2X+C_3Y.$$

Second Order

$$Z=C_1+C_2X+C_3Y+C_4X^2+C_5XY+C_6Y^2$$

Third Order

$$Z=C_1+C_2X+C_3Y+C_4X^2+C_5XY+C_6Y^2+C_7X^3+C_8X^2Y+C_9XY^2+C_{10}Y^3$$

Fourth Order

$$Z=C_1+C_2X+C_3Y+C_4X^2+C_5XY+C_6Y^2+C_7X^3+C_8X^2Y+C_9XY^2+C_{10}Y^3$$
$$+C_{11}X^4+C_{12}X^3Y+C_{13}X^2Y^2+C_{14}XY^3+C_{15}Y^4$$

Input to CONTOUR consists of the order of the surface, number of coefficients, and a string of coefficients in a free format (see section 3 for format). No end of data specification is required.

Type 3 This type of input specifies the GRID VALUES directly. Normally these will have been generated in a previous CONTOUR run. Input data consists of the number of rows and columns of the grid and the set of values in free format (see section 3).

The order of the GRID POINT values is row by row from left to right for each row. Neither input format nor end of data indication are required. A value of -1E30 will be interpreted the same as a blank value and no contours will be drawn based on such a point. The grid input is identical to the output produced by the PUNCH grid option. Use of

this option means a subsequent run will not be required to recalculate GRID VALUES.

Type 4 This option uses X, Y, Z data and the plane coefficients generated from them in a previous run. This option may be useful when it is desired to produce more than one contour map for a set of data. This may be desirable to obtain the optional set of control parameters. Data for this option is produced by the WRITE COEFFICIENTS output option. The unit number of the file must be specified as one of 8, 9, or 10.

Type 5 This option is used to input a set of GRID POINTS generated by a previous CONTOUR run using the WRITE GRID output option. Input parameters required for this option are similar to Type 4. It may be useful to save and restore GRID POINTS if changes are to be made which affect the plotting of the contours. For example, the second map could have a different contour interval. With this option, however, it is not possible to annotate the original data points as they are not preserved.

OUTPUT OPTIONS

Several output options are available for operations such as printing the data, punching cards,or writing to a file. Different types of data can be output. Following is a description of the available options:

PRINT DATA Any type of input can be printed as required.

PRINT COEFFICIENTS

This lists the coefficients of the PLANE surfaces fitted through each individual DATA POINT. The data is printed in a sorted sequence of X,Y,Z. (Data is sorted on the Y coordinate.)

PRINT GRID

This lists the entire grid. The grid numbers produced begin at the lower left corner and continue across each row from left to right.

WRITE COEFFICIENTS

This option creates a file of DATA POINTS and their associated PLANE coefficients. An identification record is also written at the beginning of the file.

Several sets of COEFFICIENTS may be written on one file. This output can then be rewound and input to succeeding CONTOUR operations as INPUT TYPE 4.

WRITE GRID

This option creates a file of GRID POINTS. Several sets of GRID POINTS may be written on the same file. This file becomes INPUT TYPE 5 in following runs.

PUNCH GRID

This punches GRID POINTS in the format described for INPUT TYPE 3. This feature can be used to modify the GRID points calculated by the program.

III. CONTROL CARD DESCRIPTIONS

The control cards required to use the CONTOUR program consist of three types: system control cards, CONTOUR parameter cards, and data if required.

SYSTEM CONTROL CARDS

Following are two examples of the control cards required to run CONTOUR II at DTNSRDC on the CDC 6000 system. For each run the user must supply his own tape (slot or bin number) to record the Calcomp plotting instructions. After the run, the user must submit a request slip to have the tape processed for Calcomp hardcopy output.

1) This is the set of control cards required if X,Y,Z coordinates exist on cards.

```
CAEMCT,CM60000,T180,P2,MT1.
CHARGE,xxxx,nnnnnnnnnn.
ATTACH,CONTUR,CAMVCONTOURTSK,ID=CAMV.
VSN(TAPE11=CBxxxx)       bin tape
REQUEST,TAPE11,HI,RING.
CONTUR.
789
  Program parameter cards
  X,Y,Z data cards
ENDMAP
9
6789
```

11 is the FORTRAN unit number to which the program writes the Calcomp plotting instructions.

2) This example assumes the input data exists on a file CAVEELEVATIONS and is to be read by CONTOUR on FORTRAN logical unit 9 (CDC file TAPE9). The program control cards (types 1-6 including ENDMAP and last card (9)) are on a file called CONTROL.

```
CAEMCT,CM60000,T180,P2,MT1.
CHARGE,xxxx,nnnnnnnnnn.
ATTACH,CONT,CAMVCONTOURTSK,ID=CAMV.
ATTACH,TAPE9,CAVEELEVATIONS,ID=CAVE.
ATTACH,CONTROL,CAEMCONTROLCRDS,ID=CAEM.
VSN(TAPE11=SLOT13=CAEMHC)       slot tape
REQUEST,TAPE11,HI,RING.
CONT,CONTROL.
789
6789
```

FORTRAN units 8, 9, and 10 may be used for input as CDC files TAPE8, TAPE9, and TAPE10. Any files defined as direct access must be ATTACHed.

The program internally uses files TAPE92 and TAPE93. These are used principally for saving temporary grid files and must not be disturbed by the user.

CONTOUR PARAMETER CARDS

There are six parameter cards required by CONTOUR. These are Map Title Card, Contour Map Parameter Card, INPUT/OUTPUT Card, Processing Parameter Card, Plot Parameters Card and Extra Options Card. All cards must be included in the specified order. All cards except the Map Title Card are in Free Format.

Free format (or List Directed) input data consists of a string of parameter values separated by one or more blanks, a comma, or a slash. When the value separator is a slash, remaining list elements for that card are treated as nulls, that is, the values set in the program are used.

To repeat a value, an integer repeat constant is followed by an asterisk and the constant to be repeated. Variables of differing types should not be repeated with the same constant. For example, to read X,Y,I,J the user must input 2*7,2*7, and not 4*7 (assuming X and Y are real and I and J are integer). For more information on free format input, see CONTROL DATA FORTRAN Extended Version 4 Reference Manual.

Map Title Card — This card specifies a title for the map. The title is printed as the output heading and plotted above the map.

Col. 1: 1

Col. 2-79: Any desired title information

Contour Map Parameter Card

This card contains variables which are related to the size and scale of the contour map. There are no defaults for any field on this card.

Parameter 1:	2
Parameter 2:	X-ORIGIN - the value of X at the lower left in DATA UNITS.
Parameter 3:	X-GRID - the number of data units along the side of a GRID square parallel to the X axis.
Parameter 4:	Y-ORIGIN - the Y-value in data units at the lower left corner of the map.

Parameter 5:	Y-GRID VALUE - the number of data units along the side of a GRID square parallel to the Y-axis.
Parameter 6:	CONTOUR INTERVAL - the number of Z data units between successive contours.
Parameter 7:	COLUMNS - the number of columns in the GRID to be superimposed over the map area. This number minus 1 times the X-GRID SIZE determines the map length in inches.
Parameter 8:	X-GRID SIZE - the length of the X side of a GRID square in inches.
Parameter 9:	ROWS - the number of rows in the GRID to be superimposed over the map area. This number minus 1 times the Y-GRID SIZE will give the height of the map in inches.
Parameter 10:	Y-GRID SIZE - the number of inches along the Y side of a GRID square.
INPUT/OUTPUT Card	This card is used to select any desired input and output options and also to describe the input data.
Parameter 1:	3
Parameter 2:	INPUT TYPE = 1: Data records in X,Y,Z coordinates. Records may be free format or variable format specified as input. End of coordinate values is indicated by a 99 on the last record. = 2: Data records are trend surface coefficients input in free format. = 3: Data records are GRID POINTS in free format. = 4: Data records are X,Y,Z coordinates and plane coefficients on a file generated by the WRITE COEFFICIENTS option (Parameter 13) = 5: Data records are GRID POINTS on a file generated by the WRITE GRID option (Parameter 14).

Parameter 3:	INPUT UNIT - Fortran logical unit of the input data. The card reader is 5. Files may be on any of the units 8, 9 or 10.
Parameter 4:	REWIND - Enter a 1 if the input unit is to be rewound (positioned at start) before reading. The card reader cannot be rewound.
Parameter 5:	INPUT JOB - this applies only to Input Types 4 and 5 where the input file was created by a previous contour run or step. It is the number of the job in which the data was created. It is a sequential number corresponding to map sequence. This number is printed at run time for each job step.
Parameter 6:	X POSITION - this specifies whether the X variable is the first (1), second (2) or third (3) variable on input. The default value is 1.
Parameter 7:	Y POSITION - this specifies the position of Y coordinate as 1, 2 or 3. Default value is 2.
Parameter 8:	Z POSITION - similar for Z-coordinate position. Default is 3.
Parameter 9:	END TEST POSITION - the value 0 or 1 to indicate that the position of end of record characters 99 and read with an A2 format is either the first (0) or last (1) variable. This entry required only for Input Type 1.
Parameter 10:	PRINT DATA = 1 to list the input data = 0 otherwise (default)
Parameter 11:	PRINT COEFFICIENTS = 1 to print the PLANE coefficients = 0 otherwise (default)
Parameter 12:	PRINT GRID = 1 to list the GRID POINTS = 0 otherwise (default)

Parameter 13: WRITE COEFFICIENTS - Fortran logical unit on which coefficients are to be written if this is desired; valid entries are 8, 9 or 10. (Default=0, no coefficients written.)

Parameter 14: WRITE GRID - Fortran logical unit for GRID if it is to be saved. Valid entries are 8, 9 or 10. Default =0 (no GRID file).

Parameter 15: PUNCH GRID

= 1 if grid file is to be punched (CDC file=TAPE7).

= 0 otherwise.

Parameter 16: VARIABLE FORMAT FLAG - for Input Type 1. This is the flag to indicate whether the data records are to be read in a particular format or in free format.

= 0 free format

= 1 variable format

The variable format is input on the following card in 6A10 format. It must be enclosed in parentheses. An A2 specification must be included as either the first or last field. This will be the position of the two nines (99) entered in the last record of the input file.

(PLEASE NOTE: Using the WRITE GRID or WRITE COEFFICIENTS one must remember the job number of the step as it is printed out or the data cannot be read back again.)

Processing Parameter Card

This card is used to select the parameters used in determining the CONTOUR GRID. Entries not specified will take the standard system default value.

Parameter 1: 4

Parameter 2: NUMBER OF OCTANTS - the minimum number of octants around each DATA POINT which must be filled with NEIGHBOR'S to ensure the DATA POINTS inclusion in the contouring process. The default is 5.

Parameter 3: WEIGHTING FACTOR FOR THE DATA POINTS - the factor to be used in weighting a NEIGHBOR'S contribution to the PLANE surface fitted through the DATA POINT. The default value of -2 is approximately equivalent to weighting according to the inverse square of the distance between the DATA POINT and its neighbor.

Parameter 4: NUMBER OF NEIGHBORS - the number of closest NEIGHBORS to a GRID POINT which will be used for determining a value at that GRID POINT. The default is 10 and the maximum permissible is 20.

Parameter 5: WEIGHTING FACTOR FOR GRID - the factor to be used in weighting contributions to the GRID POINT value from the PLANES of the neighboring DATA POINTS. The default value is -2.

Parameter 6: RANGE - the radius in inches of the search area around a GRID POINT. The NUMBER OF NEIGHBOR's must be found within this radius if the GRID POINT is to be evaluated. The default is 5.0.

Plot Parameters Card

Users may alternate 3 pens in one job. Colors green, red, blue and black are available. The basic setup for the Calcomp 936 is:

Pen 1 - black
Pen 2 - blue
Pen 3 - red

A change in pen arrangement will increase the basic charge rate. If the various pen options are used (other than 1) one must be certain to give the plotter operator the appropriate instructions.

Parameter 1: 5

Parameter 2: WIDTH - the maximum width of paper (in inches) to be used when drawing the map. If the size of map is greater than this width, the map will be drawn in as many segments as it requires, each of which

is the specified width. Approximately 1.5 inches is required for title information and so for 11-inch paper a value of 9 is usually optimal. The default value is 28.

Parameter 3: PLOT TITLE

= 0 no title plotted (default)

= 1 through 3 if title is to be plotted with corresponding pen.

Parameter 4: PLOT AXIS - 0 to 3 have same significance as PLOT TITLE.

Parameter 5: PLOT SYMBOLS - 0 to 3 as above.

Parameter 6: SYMBOL NUMBER - any nonzero number will select the corresponding plotter symbol (see SYMBOL TABLE in the plotter manual) to be drawn at the X,Y location of each data point. Default is the symbol X.

Parameter 7: SYMBOL SIZE - height of symbols in inches; default is .07.

Parameter 8: PLOT DATA - 0-3 with same significance as PLOT TITLE. Default = 0.

Parameter 9: DATA SIZE - the height in inches at which the data values will be drawn if PLOT DATA≠0 (Parameter 8). Default=.07.

Parameter 10: DATA POSITION

= 0 if posted data values are to be centered on the DATA POINT position.

= 1 if values to be posted to the right of the DATA POINT.

= 2 for above the point.

= 3 to the left of the point.

= 4 for below the data point.

Parameter 11: DATA ANGLE - the angle in degrees at which data values are to be posted. This angle is measured in degrees from the positive X-axis. Default=0.

Parameter 12:	DATA FORMAT - the number of decimal places to the right of the decimal point. Default=0 (none).
Parameter 13:	PLOT HEAVY CONTOURS - pen number 1-3 or 0 for no plot. Same as PLOT TITLE. Heavy contours are plotted twice to give a bold line.
Parameter 14:	PLOT LIGHT CONTOURS - 0-3 as above.
Parameter 15:	ANNOTATE HEAVY CONTOURS - a value 0 to 3 as above. If nonzero, the numerical value of the heavy contour lines will be plotted along the contour line.
Parameter 16:	ANNOTATE LIGHT CONTOURS - same as above (Parameter 15) except for light contours.
Parameter 17:	ANNOTATION SIZE - the height (in inches) at which contour annotations are to be drawn. Default value = 0.1 inches.
Parameter 18:	ANNOTATION FORMAT - number of decimal places to the right of the decimal point for contour annotation. Default=0 (none).
Parameter 19:	HEAVY CONTOUR FREQUENCY - a number N such that every Nth contour will be drawn heavy.
Parameter 20:	MINIMUM ANNOTATION LENGTH - a value in inches such that any contours shorter than this value will not be annotated. Default=5 inches.
Parameter 21:	MINIMUM NUMBER OF POINTS - a value such that any contour based on fewer defining points will not be drawn. The default value is 4. For maps to be drawn in more than one segment this parameter should be specified equal to 1.
Parameter 22:	MINIMUM LENGTH OF CONTOURS - a value in inches such that any contours which are shorter than this value will not be drawn. The default value is 3 times the GRID SIZE specified. If maps are to be drawn in more than one segment this parameter should be set to 0.01 in order to ensure matching of contour lines at the boundaries.

Parameter 23:	CONTOUR LOWER LIMIT - any contours below this value will be omitted.
Parameter 24:	CONTOUR UPPER LIMIT - any contours above this value will be omitted. If both contour limits are zero, the contour limits are chosen from the data.
Parameter 25:	MAP SEPARATION - the contour map will be plotted in the normal fashion up to and including this contour level. Then a new map will be started beginning with this contour level. This is the feature called MAP SEPARATION discussed in Section II. If the following two parameters are zero, all contours are drawn on one map.
Parameter 26:	PLOT HEAVY CONTOURS - same as Parameter 13 except applies to separated map.
Parameter 27:	PLOT LIGHT CONTOURS - as Parameter 14 for separated map.
Parameter 28:	ANNOTATE HEAVY - as Parameter 15 for separated map.
Parameter 29:	ANNOTATE LIGHT - as Parameter 16 for separated map.

Extra Options Card

Parameter 1:	6
Parameter 2:	SUPERIMPOSITION FLAG - flag to define a superimposition of one map on another. = 0 no superimposition = 1 superimpose this map with the next. Default value is 0.
Parameter 3:	NOISE TOLERANCE - a value which determines when a contour has no real meaning. When two Z-values on the grid are less than or equal to this value in distance, that contour will be eliminated. Default value is 0.0001.
Parameter 4:	DASH LENGTH - real number to define the length in inches of a dash or space in the dashed lines. Default value is 0.06.

Parameter 5: DASH PATTERN - integer number to define the pattern of the dashed line contours. Default value is 0 (no dashed lines). The dash pattern is a 12-bit pattern with each bit representing a one dash length interval along the contour.

Dash Pattern	Value	Dash Pattern	Value
- - - - - -	2730	———— ——	4078
— — — —	3510	———— - -	4074
—— —— ——	3789	——— - - -	4010
—— ——	3900	—— —— - -	3818
——— ———	4030	—— —— -	3962
——————	4094	—— - - - -	3754
—————	4092	— — —	3276
————	4032	- - - -	2340
—— - —— -	3770	—— - -	3876
——— —	4044	—— -	3976

Parameter 6: JUNIT - tape number where outline points are located. Outline points may define some body or detail to be superimposed on the contour map. Default value is 0 (for no outline points).
= 5 for card input
= 8,9,10 for permanent file or tape input

ENDMAP A card with ENDMAP typed in A6 format must appear between each two sets ofdata cards to produce a contour map.

End of Job The last ENDMAP card of the last set of data cards may be followed by a card with a "9" in col. 1, or by a 7/8/9 "end of record" card (or 6/7/8/9 "end of file" card if the input file is

other than the card reader).

INPUT DATA CARDS

Following is an explanation of the preparation of the five different input types.

Input Type 1 - X,Y,Z Coordinates

This data may be input in free format or a particular format may be specified by setting the flag in Parameter 16 of the Input/Output card. In either case, data consists of one set of X,Y,Z coordinates per record. The series of input data points must be terminated with a record containing the characters 99. Any X,Y,Z values appearing on the 99 card are ignored. Special care must be taken if the free format is used. Free format will always expect to read four parameters per record unless a slash is encountered. Therefore, each data record must read X,Y,Z,0 or X,Y,Z/ and the end record must read 0.,0.,0.,99; or, depending on the end test position indicator, 0,X,Y,Z for each data record and 99,0.,0.,0. or 99/ for the end record. It may facilitate the free format input to indicate that the 99 will be the last characters of the record (i.e., Parameter 9=1 on Input/Output card).

Input Type 2 - Trend Surface Coefficients

This type of data is read in free format. The data record consists of the order of the trend surface (1,2,3,4), the number of coefficients (3,6,10,15, respectively) followed by the coefficients. No end of data specification is required.

Input Type 3 - Grid Points

This type of data is read in free format. The first record contains the number of rows and the number of columns in the grid. Each succeeding record (as many as required) contains up to seven grid point values

Input Types 4 and 5

These are formats internal to the program produced using the appropriate read and write options. Input option TYPE=5 must have parameter 5 of card 5 equal to 0 (plot symbols) and parameter 8 of card 5 equal to 0 (plot data) or the program will fail.

OUTLINE INPUT DATA CARDS

Outline points are specified as X,Y coordinate pairs. They are read in free format, one pair per record. To lift the pen (specify a "hole") the user inputs 998., 998. . The end of data indicator is 999., 999. .

V. SAMPLE RUN

Below is a sample of a simple, straightforward CONTOUR run. One map was produced from one set of X,Y,Z coordinates. The input was as follows:

```
CAEMCT,CM6000,T180,P3,MT1.          1843/MARQUARDT
CHARGE,CAEM,nnnnnnnnnn.
ATTACH,CONT,CAMVCONTOURTSK,ID=CAMV.
VSN(TAPE11=CB0536)
REQUEST,TAPE11,HI,RING.
CONT.
789
1  TEST CONTOUR MAP
2,100.,5.,100.,5.,5.,21,.4,21,.4
3,1,5,0,0,0,0,0,1,1,1,1,0,0,0,1
(F3.0,2F4.0,A2)
4,3,0,7,0,10.
5,8.,1,1,1,2,.02,1,.07,0,0.,0,1,1,1,1,.1,0,5,10*0
6,5*0
148 125 140
122 131 145
143 145 152
158 149 146
115 155 155
135 157 173
155 165 156
185 168 145
165 170 157
135 172 154
112 181 145
175 182 170
153 183 143
149 186 140
182 193 145
           99
ENDMAP
9
6789
```

This job consists of 15 data points having the following minima and maxima.

	Minimum	Maximum
X	112	185
Y	125	193
Z	140	173

Both the X origin and Y origin have been chosen as equal to 100. The maximum required for both X and Y is 200. A grid size of 5 data units corresponding to .4 inches has been selected. The range of both X and Y is 100 data units, therefore, at 5 units per grid square, 20 squares, (X and Y in this case) are required. Hence, the number of columns and number of rows in the grid matrix both equal 21 for a total of 441 GRID points (21 x 21). The map size is .4 x 20 (both directions) or 8 inches by 8 inches. The input is from card images, hence the input unit is 5. The order of the coordinates is X,Y,Z and the input format is (F3.0,2F4.0,A2). The A2 is for the 99 value in the last record used to signal the end of the data. Output requests are:

- a list of the input data.
- a list of the coefficients of the PLANES generated.
- a list of the GRID matrix created.

```
       J O B    1

  TEST CONTOUR MAP

       M A P    P A R A M E T E R S

SIZE IN ORIGINAL DATA UNITS

    X -    100.000 UNITS TO    200.000 UNITS    GRID SIZE -      5.000 UNITS

    Y -    100.000 UNITS TO    200.000 UNITS    GRID SIZE -      5.000 UNITS

PHYSICAL MAP SIZE

    X -  8.00 INCHES     GRID SIZE  .40 INCH

    Y -  8.00 INCHES     GRID SIZE  .40 INCH

SIZE IN COMPUTER

     21 COLUMNS BY  21 ROWS     TOTAL    441 GRID SQUARES

       I N P U T - O U T P U T    P A R A M E T E R S

INPUT INDICATED - X,Y,Z DATA IN BCD

    INPUT UNIT  5             PRINT DATA  1
    REWIND  0                 PRINT COEFFICIENTS  1
    INPUT JOB  0              PRINT GRID  1
    X VARIABLE  1             OUTPUT COEF ON UNIT  0
    Y VARIABLE  2             OUTPUT GRID ON UNIT  0
    Z VARIABLE  3             OUTPUT GRID ON CARDS  0
    POS. OF END TEST  1       INPUT FORMAT (F3.0,0,A2)
```

```
    P R O C E S S I N G   P A R A M E T E R S

NUMBER OF OCTANTS WHICH MUST BE FILLED WHEN EVALUATING DATA POINT PLANES 3

THE S VARIABLE IN THE WEIGHTING FUNCTION USED IN CALCULATING DATA POINT PLANES -2.000

NUMBER OF DATA POINT PLANES TO BE USED WHEN EVALUATING GRID POINTS  7

THE S VARIABLE IN THE WEIGHTING FUNCTION USED IN CALCULATING GRID POINTS -2.000

RADIUS OF SEARCH FOR DATA TO BE USED IN PLANE OR GRID EVALUATION 10.000

    P L O T   P A R A M E T E R S .

FOLLOWING ARE THE GENERAL PLOTTING DIRECTIONS FOR THE MAP -

    PLOT TITLE  1                        PLOT HEAVY CONTOUR LINES  1
    PLOT AXIS  1                         PLOT LIGHT CONTOUR LINES  1
    PLOT SYMBOLS  1                      ANNOTATE HEAVY CONTOUR LINES  1        ZERO MEANS DO NOT PLOT
    PLOT DATA ANNOTATION  1              ANNOTATE LIGHT CONTOUR LINES  1

            PART TWO OF A SEPARATED MAP                                         1 MEANS USE PEN 1
                                                                                2           PEN 2
    PLOT HEAVY CONTOUR LINES  0          ANNOTATE HEAVY CONTOUR LINES  0        3           PEN 3
    PLOT LIGHT CONTOUR LINES  0          ANNOTATE LIGHT CONTOUR LINES  0        4           PEN 4

FOLLOWING ARE THE PLOTTING DETAILS

    PLOTTER WIDTH   8.
    TYPE OF SYMBOL   2
    SIZE OF SYMBOL ANNOTATION  .12
    SIZE OF DATA ANNOTATION  .07
    DATA ANNOTATION PLACEMENT - POSITION  0
    ANGLE OF DATA ANNOTATION   0.
    NUMBER OF DECIMALS IN DATA ANNOTATION  0
    SIZE OF CONTOUR ANNOTATION  .10
    NUMBER OF DECIMALS IN CONTOUR ANNOTATION  0
    NUMBER OF LIGHT CONTOUR LINES BETWEEN HEAVY LINES  5
    LENGTH OF CONTOUR LINE REQUIRED FOR ANNOTATION   5.
    MINIMUM NUMBER OF POINTS DEFINING CONTOUR LINE    4
    MINIMUM LENGTH OF CONTOUR LINE 1.20
    LOWER CONTOUR LIMIT       0.000
    UPPER CONTOUR LIMIT       0.000
    SEPARATION CONTOUR LEVEL       0.000


    CONTOUR INTERVAL       5.000 UNITS

ADDITIONAL PLOTTING OPTIONS
NO SUPERPOSITION
NOISE TOLERANCE =      .0001
NO OUTLINE POINTS
DASH LENGTH =     .060ASH PATTERN =     0
```

E X E C U T I O N   M E S S A G E S

```
READING X,Y,Z DATA IN BCD - START =    .223 SECONDS
                          -   END =    .270 SECONDS
                          - TOTAL =    .047 SECONDS

                NO. OF DATA POINTS =    15
```

C O O R D I N A T E S   O F   C O N T O U R I N G   D A T A

X	Y	Z
148.00000000	125.00000000	140.00000000
122.00000000	131.00000000	145.00000000
143.00000000	145.00000000	152.00000000
158.00000000	149.00000000	146.00000000
115.00000000	155.00000000	155.00000000
135.00000000	157.00000000	173.00000000
155.00000000	165.00000000	156.00000000
185.00000000	168.00000000	145.00000000
165.00000000	170.00000000	157.00000000
135.00000000	172.00000000	154.00000000
112.00000000	181.00000000	145.00000000
175.00000000	192.00000000	170.00000000
153.00000000	183.00000000	143.00000000
149.00000000	186.00000000	140.00000000
182.00000000	193.00000000	145.00000000

E X E C U T I O N   M E S S A G E S

```
EVALUATION OF PLANES THROUGH DATA POINTS - START =    .327 SECONDS
                                         -   END =    .353 SECONDS
                                         - TOTAL =    .026 SECONDS
```

C O E F F I C I E N T S   O F   P L A N E S   T H R O U G H   D A T A   P O I N T S

C(1)	C(2)*X	C(3)*Y
.3702667E+03	.1333333E+00	-.2000000E+01
.4819412E+02	.1176471E+00	.6294118E+00
.1701725E+03	-.8712349E+00	.7338900E+00
.1624946E+03	-.7424284E+00	.6765711E+00
-.6961538E+02	.1538462E+01	.3076923E+00
.1670287E+03	-.5486018E-01	.8520648E-01
.1640358E+03	-.6199563E-01	.9536278E-02
-.2928571E+01	-.7571429E+00	.1714286E+01
.7306783E+02	.7226048E+00	-.2076331E+00
.3636961E+03	-.2003600E+00	-.1061904E+01
.1532813E+03	-.2343750E-01	-.3125000E-01
.2465808E+03	-.2200600E+00	-.2091773E+00
.2266405E+03	.4673802E+00	-.8478126E+00
.2990942E+03	-.1389623E+00	-.7440260E+00
-.2956000E+03	.3000000E+00	.2000000E+01

E X E C U T I O N   M E S S A G E S

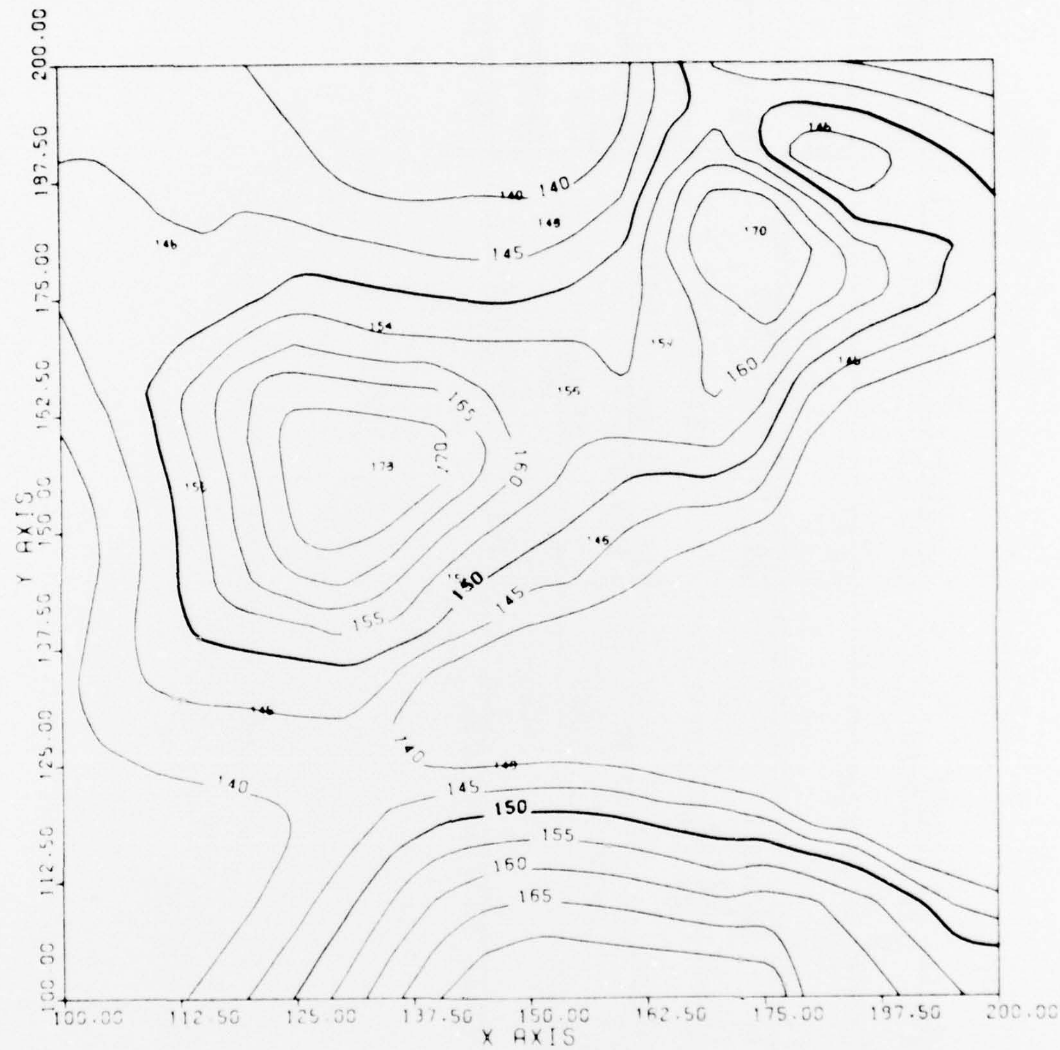
```
DETERMINATION OF CONTOUR GRID - START =     .424 SECONDS
                              -   END =    2.092 SECONDS
                              - TOTAL =    1.658 SECONDS
        NUMBER OF GRID POINTS EVALUATED =    441
CONTOURING LIMITS CHOSEN - LOWER =   .14000E+03
                         - UPPER =   .17300E+03
```

GRID MATRIX CREATED FROM DATA

1	.1329E+03	.1353E+03	.1380E+03	.1413E+03	.1454E+03	.1505E+03	.1569E+03	.1636E+03	.1697E+03	.1743E+03
11	.1773E+03	.1772E+03	.1764E+03	.1763E+03	.1764E+03	.1764E+03	.1624E+03	.1614E+03	.1598E+03	.1559E+03
21	.1523E+03	.1323E+03	.1343E+03	.1364E+03	.1398E+03	.1421E+03	.1467E+03	.1528E+03	.1596E+03	.1656E+03
31	.1698E+03	.1718E+03	.1715E+03	.1707E+03	.1639E+03	.1690E+03	.1676E+03	.1620E+03	.1604E+03	.1564E+03
41	.1525E+03	.1502E+03	.1326E+03	.1342E+03	.1357E+03	.1374E+03	.1397E+03	.1433E+03	.1486E+03	.1551E+03
51	.1608E+03	.1643E+03	.1656E+03	.1651E+03	.1642E+03	.1628E+03	.1612E+03	.1623E+03	.1609E+03	.1567E+03
61	.1526E+03	.1446E+03	.1418E+03	.1336E+03	.1351E+03	.1362E+03	.1372E+03	.1385E+03	.1408E+03	.1448E+03
71	.1503E+03	.1550E+03	.1575E+03	.1583E+03	.1579E+03	.1568E+03	.1550E+03	.1526E+03	.1534E+03	.1504E+03
81	.1474E+03	.1390E+03	.1363E+03	.1333E+03	.1352E+03	.1369E+03	.1379E+03	.1385E+03	.1391E+03	.1402E+03
91	.1423E+03	.1452E+03	.1477E+03	.1492E+03	.1498E+03	.1497E+03	.1485E+03	.1464E+03	.1455E+03	.1432E+03
101	.1353E+03	.1317E+03	.1310E+03	.1283E+03	.1251E+03	.1370E+03	.1392E+03	.1404E+03	.1409E+03	.1413E+03
111	.1419E+03	.1425E+03	.1412E+03	.1395E+03	.1396E+03	.1402E+03	.1404E+03	.1394E+03	.1374E+03	.1345E+03
121	.1311E+03	.1280E+03	.1257E+03	.1237E+03	.1211E+03	.1182E+03	.1384E+03	.1414E+03	.1433E+03	.1430E+03
131	.1442E+03	.1448E+03	.1450E+03	.1410E+03	.1339E+03	.1308E+03	.1309E+03	.1315E+03	.1312E+03	.1308E+03
141	.1280E+03	.1258E+03	.1241E+03	.1212E+03	.1180E+03	.1158E+03	.1149E+03	.1384E+03	.1428E+03	.1459E+03
151	.1473E+03	.1476E+03	.1482E+03	.1491E+03	.1461E+03	.1396E+03	.1336E+03	.1300E+03	.1295E+03	.1299E+03
161	.1288E+03	.1270E+03	.1252E+03	.1230E+03	.1135E+03	.1158E+03	.1148E+03	.1162E+03	.1371E+03	.1422E+03
171	.1471E+03	.1511E+03	.1529E+03	.1543E+03	.1564E+03	.1546E+03	.1502E+03	.1454E+03	.1402E+03	.1382E+03
181	.1364E+03	.1336E+03	.1308E+03	.1283E+03	.1245E+03	.1194E+03	.1173E+03	.1173E+03	.1170E+03	.1363E+03
191	.1412E+03	.1469E+03	.1534E+03	.1597E+03	.1644E+03	.1664E+03	.1616E+03	.1549E+03	.1503E+03	.1470E+03
201	.1451E+03	.1417E+03	.1384E+03	.1359E+03	.1326E+03	.1256E+03	.1210E+03	.1194E+03	.1184E+03	.1186E+03
211	.1364E+03	.1411E+03	.1469E+03	.1540E+03	.1622E+03	.1700E+03	.1719E+03	.1696E+03	.1618E+03	.1556E+03
221	.1522E+03	.1490E+03	.1453E+03	.1424E+03	.1411E+03	.1386E+03	.1324E+03	.1291E+03	.1274E+03	.1275E+03
231	.1282E+03	.1377E+03	.1420E+03	.1478E+03	.1550E+03	.1633E+03	.1719E+03	.1732E+03	.1728E+03	.1708E+03
241	.1634E+03	.1569E+03	.1532E+03	.1500E+03	.1486E+03	.1488E+03	.1451E+03	.1364E+03	.1295E+03	.1249E+03
251	.1226E+03	.1234E+03	.1397E+03	.1438E+03	.1437E+03	.1569E+03	.1651E+03	.1723E+03	.1733E+03	.1731E+03
261	.1717E+03	.1650E+03	.1572E+03	.1558E+03	.1550E+03	.1557E+03	.1568E+03	.1511E+03	.1403E+03	.1338E+03
271	.1302E+03	.1276E+03	.1256E+03	.1422E+03	.1458E+03	.1509E+03	.1575E+03	.1645E+03	.1686E+03	.1678E+03
281	.1664E+03	.1654E+03	.1604E+03	.1563E+03	.1560E+03	.1554E+03	.1577E+03	.1607E+03	.1567E+03	.1458E+03
291	.1402E+03	.1370E+03	.1346E+03	.1325E+03	.1443E+03	.1463E+03	.1483E+03	.1517E+03	.1570E+03	.1602E+03
301	.1580E+03	.1562E+03	.1559E+03	.1555E+03	.1554E+03	.1553E+03	.1542E+03	.1570E+03	.1611E+03	.1627E+03
311	.1541E+03	.1486E+03	.1453E+03	.1424E+03	.1335E+03	.1452E+03	.1458E+03	.1458E+03	.1464E+03	.1491E+03
321	.1526E+03	.1521E+03	.1509E+03	.1500E+03	.1433E+03	.1498E+03	.1514E+03	.1534E+03	.1570E+03	.1641E+03
331	.1681E+03	.1635E+03	.1576E+03	.1530E+03	.1435E+03	.1450E+03	.1453E+03	.1454E+03	.1451E+03	.1451E+03
341	.1459E+03	.1471E+03	.1466E+03	.1456E+03	.1444E+03	.1441E+03	.1443E+03	.1465E+03	.1502E+03	.1604E+03
351	.1700E+03	.1702E+03	.1657E+03	.1572E+03	.1528E+03	.1502E+03	.1482E+03	.1452E+03	.1452E+03	.1450E+03
361	.1449E+03	.1449E+03	.1440E+03	.1413E+03	.1406E+03	.1403E+03	.1407E+03	.1405E+03	.1420E+03	.1455E+03
371	.1581E+03	.1676E+03	.1678E+03	.1572E+03	.1460E+03	.1462E+03	.1484E+03	.1497E+03	.1450E+03	.1450E+03
381	.1448E+03	.1446E+03	.1439E+03	.1417E+03	.1394E+03	.1365E+03	.1365E+03	.1369E+03	.1367E+03	.1373E+03
391	.1415E+03	.1520E+03	.1581E+03	.1518E+03	.1412E+03	.1418E+03	.1468E+03	.1499E+03	.1527E+03	.1446E+03
401	.1445E+03	.1443E+03	.1437E+03	.1423E+03	.1392E+03	.1351E+03	.1328E+03	.1325E+03	.1327E+03	.1328E+03
411	.1336E+03	.1386E+03	.1479E+03	.1527E+03	.1504E+03	.1488E+03	.1503E+03	.1531E+03	.1560E+03	.1505E+03
421	.1439E+03	.1437E+03	.1432E+03	.1422E+03	.1400E+03	.1363E+03	.1318E+03	.1291E+03	.1284E+03	.1286E+03
431	.1290E+03	.1309E+03	.1376E+03	.1478E+03	.1552E+03	.1576E+03	.1588E+03	.1603E+03	.1621E+03	.1640E+03
441	.1657E+03									

```
          E X E C U T I O N   M E S S A G E S

BEGINNING OF PLOTTING OPERATIONS -    2.506 SECONDS

PLOT TAPE INITIALIZED
PLOT TAPE BLOCK NUMBER     1 - REORIGINING FOR MARGIN
PLOT TAPE BLOCK NUMBER     2 - MAP TITLE    PEN  1
PLOT TAPE BLOCK NUMBER     3 - AXES    PEN  1
PLOT TAPE BLOCK NUMBER     4 - DATA MARKER AND ANNOTATION    PEN  1

SYMBOLS AND/OR DATA ANNOTATION COMPLETED IN -    2.568 SECONDS

PLOT TAPE BLOCK NUMBER     5 - HEAVY CONTOURS    PEN  1 , LIGHT CONTOURS    PEN  1
                               HEAVY CONTOUR ANNOTATION    PEN  1, LIGHT CONTOUR ANNOTATION  PEN 1

CONTOURING COMPLETED IN  7.208 SECONDS

SEGMENT  1. COMPLETED IN -    7.208 SECONDS

ELAPSED TIME TO DATE =    11.150 SECONDS


THE NUMBER OF CALCOMP BLOCKS IN THIS FILE IS         7
        PLOT TAPE BLOCK NUMBER  999. - PLOTTING COMPLETED


        END OF JOB



        NSRDC 6700 SCOPE 3.4.3  E+10 76216
 09.51.54.CAEMC6B  FROM    /AD
 09.51.54.IP  00000256 WORDS - FILE INPUT   , DC 00
 09.51.54.CAEMCT,CM60000,T100,P3,MT1.
 09.51.54.1043/MB MARQUARDT
 09.52.04.ATTACH,CONT,CAMVCONTOURTSK,ID=CAMV.
 09.52.07.PF CYCLE NO. = 002
 09.52.07.VSN(TAPE11=CB0536)
 09.52.07.REQUEST,TAPE11,HI,RING.
 09.53.42.( MT51 ASSIGNED)
 09.53.42.CONT.
 09.58.00.MT51 VOLUME SERIAL NUMBER IS  CB0536
 10.01.54.  CALCOMP936 NO. OF ID BLOCKS =   7
 10.01.54.     STOP
 10.01.54.      9.794 CP SECONDS EXECUTION TIME
 10.01.54.OP  00001056 WORDS - FILE OUTPUT , DC 40
 10.01.54.MT51  BLOCKS WRITTEN -000060
 10.01.55.MS        0  WORDS  (        0 MAX USED)
 10.01.55.CPA      10.140 SEC.
 10.01.55.CPB       1.029 SEC.
 10.01.55.IO        2.756 SEC.
 10.01.55.AMC  20759.367
 10.01.55.SS       12.031 SEC.
 10.01.55.PP       12.100 SEC.     DATE 08/24/76
 10.01.55.EST. BASIC CHARGE $    4.62
 10.01.55.EJ  END OF JOB, AD
```

TEST CONTOUR MAP



CMO CALCOMP/COM

PRIVATE ☐ CONF. ☐ SECRET ☐

DATE ✓	JOB ORDER NO. ✓	TAPE I.D. ✓	DENSITY ✓	DATE RUN
USER I.D. ✓	USERS NAME ✓	CODE ✓	EXT ✓	TIME ON OFF
STD. SETUP ✓	CALCOMP PAPER NO	COM JOB CARD NAME		TOTAL TIME
EST. TIME ✓	NO BLOCKS ✓	LABELLED YES. NO	NO FILES	NO FICHE
GRID COLOR	MARGIN RIGHT BOTTOM	FORM FLASH		NO FRAMES
COLOR PEN 1	PEN 2 PEN 3	STD. NO FICHE	OTHER NO FRAMES	FILE NO
SPECIAL INSTRUCTIONS				OPERATOR
				COMMENT

Sample Request for CalComp Processing

ACKNOWLEDGMENTS

The original CONTOUR program referred to in this report was developed by Mr. A Beharrell of the University of Calgary.

The author would like to express deep appreciation to Mr. Melvin Haas for his guiding suggestions, endless encouragement and patient tutoring. Mr. Haas is responsible for technical improvements to the contouring process and the development of the routine to produce dashed lines.

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